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ABSTRACT

The theoretical framework for a multidisciplinary science curriculum for early adolescents is described. Enhancing physical, cognitive, moral, social, and personal development of early adolescents is proposed instead of cultural transmission as the chief goal of education. Major elements of the framework include interface themes and subsumed concepts from biological, social, and behavioral sciences; generic questions that represent major concerns and interests of early adolescents; and problems that are proposed as curriculum components. An experimental three-year curriculum for eleven- to thirteen-year-olds is being developed and tested as an exemplar of the proposed theoretical framework. (Author)

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A THEORETICAL FRAMEWORK FOR MULTIDISCIPLINARY SCIENCE CURRICULA FOR EARLY ADOLESCENTS: THE BSCS HUMAN SCIENCES PROGRAM*

James T. Robinson

Biological Sciences Curriculum Study

In March, 1971, the Biological Sciences Curriculum Study initiated a new curriculum development project that differed markedly from course content improvement projects. The purpose of the project was to invent an entirely new curriculum designed to fit the physical, cognitive, social, and psychological characteristics of eleven- to thirteen-year-olds. This new curriculum would need to be flexible in its structure, because students of these age groups are served by several different administrative units: elementary schools, intermediate schools, junior high schools, and middle schools.

The Human Sciences project had its origins in a series of conferences and extensive school visitations conducted by the BSCS in 1967 and 1968. Teachers interviewed reported that an increasing proportion of their students were uninterested in school, that more students than in the past were questioning what they were studying, and that many saw little relationship between school and their lives outside the classroom. Earlier physical maturation in a social milieu of rapid cultural change, the apparent failure of the nuclear family, and a mobile population have contributed markedly to the difficulties of growing up in contemporary America.

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Recommendations to develop a new curriculum designed to meet the special needs and interests of students in early adolescence were published in Life Sciences in the Middle School (1969). The guidelines presented in this study recommended that new curricula be based on considerations of the characteristics of the target student population. The guidelines also included recommendations that a three-year interdisciplinary life sciences program be developed, and with "life sciences" broadly defined and considered in a social context. Although the terms "interdisciplinary" and "life sciences" were initially used to identify the proposed curriculum, the terms "multidisciplinary" and "human sciences" are now considered more appropriate designations. Multidisciplinary refers to the relating of several disciplines for a common purpose. This distinction is critical; for the purpose is that the disciplines serve the growth and development of students, not that students serve the disciplines. Human sciences is meant to convey the scope of the sciences that may serve as content sources for the curriculum, and to emphasize the human concerns of adolescents.

Foundations of the Curriculum Design

Four fields of knowledge were considered to be essential in developing a design for the curriculum: the learner, the society, teachers and schooling, and the natural and social science disciplines.

The characteristics of the learners, the major societal trends, suggestions for improving schooling, and those aspects of the disciplines that have been incorporated into the rationale are the result of extensive literature search, observations and interviews of adolescents and

teachers, and deliberations by those who have been involved in the Human Sciences project.

Several critical characteristics of eleven-, twelve-, and thirteen-year-olds are considered important for curriculum design. Piaget's conception of stages of cognitive development has provided a very useful system for planning and designing learning activities. His philosophic view of man coincided more closely with those of the developers than those of other psychologists. Moreover, stage development characteristics, such as those described for concrete operational thought, were found to be valuable conceptual tools in interacting with students. Selection of stage theory of cognitive development implies a long-term view of the interaction of the curriculum and the child. For curriculum construction the question asked is, "What types of curricular interventions will facilitate cognitive disequilibrium?" (Strauss, 1972).

Physical variability is a significant learner characteristic in early adolescence. The physical development that will occur in the next several years marks the most important qualitative change to take place in the individual's life.

[Insert Fig. 1 here]

The differential velocities in growth shown above for boys and girls is common knowledge, but schooling usually attempts to proceed as if this major event is not occurring. Individual growth curves vary markedly from the averaged curve shown in Figure 1. The results of such differential growth are most evident to teachers and students in classrooms: Within a single class group, students may differ in height by more than two feet and in weight by over one hundred pounds.

[Insert Fig. 2 here]

Wattenberg (1965) describes the age group as a bewildering assortment of young people at critical turning points in their lives. Bewilderment may be reduced if children of this age range are provided with curricula that include them and help them understand what is happening to them.

In personal development eleven- to thirteen-year-olds are largely egocentric, viewing objects and events in personal terms. Hobby interests are widespread and varied and students are concerned with doing and building, with conquering small bits of the environment. White (1972) finds that eleven- to thirteen-year-olds are seeking to develop competencies by being actively engaged in dealing with both the inanimate and the human environment. Erikson (1959) points out that an individual of this age is at a socially decisive stage. He must learn to produce things, "he develops industry, that is, he adjusts himself to the inorganic laws of the tool world. He can become an eager and absorbed unit of a productive situation. To bring a productive situation to completion is an aim which gradually supersedes the whims and wishes of his idiosyncratic drives and personal disappointments" (Erikson, 1959, p. 86).

Interpersonal competence -- being able to have some effect on people -- is variable, but few eleven-year-olds have developed capabilities that enable them to work effectively in large groups. The two-person group is most common when students have choice in the way they go about solving problems. It will sometimes build to three or four, but then will crumble back to two as stresses and strains develop.

The group for whom the Human Sciences program is designed can be characterized by two conceptions: variability and changeability.

Eleven-year-olds generally find adult suggestions helpful. By twelve and thirteen the same suggestions will be challenged and established belief systems will begin to be examined (Kagan, 1971). In the United States this challenge tends to focus on beliefs concerning sexuality, religion, drugs, school, and authority -- all events with which the student must cope. This inescapable developmental process is best accomplished when viewed by adults as normal and not rebellious behavior, nor should it be ignored in designing curricula.

Rapidly changing societies produce special problems for school curricula. The shifting social milieu opens up new possibilities for educational development, but quickly renders others obsolete. In a synthesis of studies of contemporary society Harman (1972) suggests that the Industrial State Paradigm, dominant in Western civilization since the Middle Ages, is beginning to break down. Its very success underlies the serious social problems of our day. Advances in communication and transportation have resulted in a high degree of interdependence that is especially vulnerable to both natural and deliberately engendered breakdown. Increased efficiency has been accompanied by the dehumanization of work. The growth in systematized knowledge has resulted in threats to privacy and freedom with the advent of surveillance technology. Increased affluence has brought about an increase in the per capita impact on the environment.

The turmoil of the social environment is not missed by adolescents. Their sensitivity to the total environment and their efforts to find motives for events suggest that curricula designed to serve needs must provide for systematic analysis of moral judgments (Kohlberg, 1969).

The growth of knowledge over the past several decades has produced a dilemma for educational programs. Simon (1971) has suggested that the growth of knowledge has produced an information-rich world with a consequent scarcity of attention. Coping with information overload has led to intuitive selection from the ever enlarging stockpile. Dexter (1973) has commented on this coping behavior by observing that "... because, for historic reasons, we focus with pride on the numerous bits of information which are available out there, we do not pay attention to the lack of ability to attend meaningfully to most of these bits of information."

As the society has become information-rich it has become action-poor for children and adolescents. The amount of direct experience has declined, but there has been a vast increase in vicarious experience (Coleman, 1971). Vicarious experience differs from direct experience in significant ways: "complexities of reality are lost, the selectivity of the camera or pen imposes an artificial unity of action, the intensity of action is increased, and the participants are polarized into heroes and villains" (Coleman, 1971, p. 115). Students become observers in a wide variety of events without the power or responsibility for affecting the action. Coleman suggests that our information-rich, open society has destroyed two classical functions of schools. "Information richness removes the function of the school in extending the child's horizons through vicarious experience; and information pluralism removes the function of the school in shaping the child's values through selectivity" (Coleman, 1971, p. 119).

Observing eleven-year-olds in test classes has exposed a need supported by Coleman's analysis. Students are critical of passive learning;

they express strongly their desire to do, to act, to manipulate things.

These data -- of the learner and of society -- resulted in approaching the disciplines as sources for the curriculum rather than as structures of the curriculum in the Human Sciences project. The science curriculum movement of the 1960's utilized the structures of the disciplines as the structure for organizing the curriculum. The issues discussed above in conjunction with the large-scale dissatisfaction of students with schools and schooling reported in many books and periodicals in the last five to seven years support the need for the development of an entirely new curriculum, one that is more consonant with the adolescent in American society. The purpose of the Human Sciences project is to create, de nova, a new curriculum based on different theoretical grounds from those of existing science programs.

Design for the Curriculum

The search for alternatives to a discipline-structured curriculum organization was conducted in the literature and through discussions with adolescents, psychologists, and teachers. From this search commonalities in the interests and concerns of students themselves began to receive serious consideration as elements of design. Reducing these questions and answers, expressed in many forms and idioms, to a small stable structure was accomplished through the concept of "generic questions." Four such questions seem to subsume the great majority of student questions and concerns, providing the stability and simplicity required for curriculum design.

The generic questions for the Human Sciences program are: Why do things change? Why do living things act as they do? What determines who gets what? and, Is there a normal?

The concept of generic questions as one curriculum structure is being tested as the curriculum materials are being developed. Generic questions have served useful functions in the development of three pilot modules and five modules for eleven-year-olds. However, they remain as philosophic constructs at this time. They may be narrowly culture-bound. There is need to examine their applicability to various sub-cultural groups, as well as their pragmatic utility for curriculum design.

Each generic question provides a context, a contextual perspective, that serves to limit and give direction to an area of study. Generic questions are too general to serve directly as parts of the curriculum, but they are utilized as a means to insure that the deep concerns of students are represented in the selection of the objects and events to be studied.

The natural, social, and behavioral sciences provide the primary sources of subject matter for the Human Sciences program. Three conferences were convened to formulate the potential interfaces between disciplines that could serve to integrate their major ideas. The conferences resulted in the development of three integrative themes: continuity and change; competition, accommodation, and cooperation; and, equality and inequality. Major ideas from the natural and social sciences were subsumed within each integrative theme.

The themes serve to restrict and guide the selection of ideas from the disciplines and to assure a multidisciplinary approach in each major

part of the curriculum materials. They are utilized as heuristic devices rather than as rigorous, logical categories.

From considerations of the learners, the society, the disciplines, and from knowledge of schools and schooling two major goals of the Human Sciences project were formulated: 1) to produce a science curriculum that would contribute to the personal and social development of eleven- to thirteen-year-olds, and 2) to produce curriculum structures, approaches to learning, and to provide for student and teacher role definitions that would actively engage students in learning to learn.

Such a program should enable many students to develop a positive self-concept; to develop interests, competence, and creativity; to develop an acceptance of others who have ideas and values different from their own; to stimulate growth in cognitive abilities consonant with cognitive needs; and to develop interpersonal and social competence.

A curriculum program designed to meet the rationale that has been described would have to exhibit a group of special characteristics. These characteristics will become, in effect, criteria by which the materials developed may be evaluated for consistency with the rationale.

If the curriculum materials are to contribute to development, the materials should:

1. relate to the physical, cognitive, psycho-social and moral developmental characteristics of the eleven- to thirteen-year-old.
2. provide a variety of activities and ways of learning, and permit students to select the activities in which they will engage.

3. provide many activities related to an idea or a problem.
4. provide activities that meet the range of interests of eleven- to thirteen-year-olds.
5. focus on student problems and concerns with concepts, principles, and modes of inquiry from the disciplines contributing substance and perspective.
6. incorporate personal and social experiences and roles of eleven- to thirteen-year-olds as objects of study.
7. incorporate the physical, social, cognitive, and personal-social development of children and adolescents as objects of study.
8. provide activities at both concrete and abstract levels, but should be especially rich in concrete activities.
9. be limited to problem areas having a clear bio-social interface, drawing from natural and social science disciplines.

Students in early adolescence need action and manipulation. They are interested, as social organisms, in people, who they are, what they think about, their likes and dislikes, and how they have developed. Some are more interested in machines and other physical objects, in animals or plants, in pets, in exotic organisms. Much of contemporary life provides only vicarious experience with organisms and materials. Direct experience with physical aspects of the environment seems to be a critical need for eleven- to thirteen-year-olds. Therefore, the curriculum should also provide students with opportunities to:

1. use a wide variety of human and material resources within their community and to learn how to go beyond the community when local resources are inadequate for their needs.

2. interact with people from a wide range of ages and backgrounds in the community in a diversity of their varied roles.
3. interact directly with a wide variety of organisms, to have first-hand experience in their care and in ways in which they can be observed and studied.
4. interact directly in constructing, operating, and manipulating physical objects.

Finally, the curriculum is intended to provide experiences that will facilitate the eventual ability of students to:

1. learn how to learn so as to develop autonomy in learning.
2. develop multifactor approaches by seeking alternative explanation to problems and to recognize the danger of simplistic explanations to problems.
3. make cross-cultural comparisons of critical bio-social issues, i.e., race relations, family structure, male-female roles, human resources, and others.
4. analyze controversial issues for their empirical and ethical elements and deal with them in socially constructive ways, utilizing available knowledge and value positions as a basis for rational action.
5. draw upon their emotions, values, and intellect as elements of creative thinking.
6. develop an understanding of man as a social and biological being in a context of relations with his own kind and with the entire living world.
7. develop confidence that phenomena are explicable in conjunction with attitudes of reasoned skepticism about explanations and interpretations.

8. practice in real problem contexts specific inquiry skills such as:
   a. observational skills of different kinds, i.e., as participant-observer, as interested observer, as observer of experimentation, as developer of operational definitions, as selector of appropriate units of measurement, etc.
   b. interviewing skills, sampling and survey research skills, etc.
   c. information display skills, i.e., tables, films, charts, etc.
   d. decision-making skills (data processing and value analysis in the application of knowledge).
   e. analytic skills, i.e., distinguishing assumptions from inferences, facts from values, empirical from ethical claims, data from interpretations, examining phenomena as systems, etc.
   f. question-asking and problem identification skills that bring initial questions into researchable questions.
9. develop interest in and curiosity about the future, both for themselves and for the civilization of which they are a part.
10. gain experience with the potentialities and limitations of the methods of scientific and social investigation.
11. develop individuality and at the same time encourage reflection on the democratic core values which lend stability to American -- there should be continuous examination

of the controversy that stems from the application of the values of individual freedom to provision for equality of opportunity.

Design of Curriculum Materials

Modular design, in the sense of units that could be easily joined and arranged, was determined to be most compatible with requirements of the program rationale. Each module is designed to provide for from five to seven weeks of instruction. Length of use is not to be prescribed, but will vary considerably from class to class. A modular design offered the characteristics of breaking the school year into discrete blocks providing end points and new beginnings that are psychologically consistent with learner characteristics. Modules were initially identified by a question that reflected a student concern or interest, such as, "How are organisms alike or different?" "How do organisms develop?" Final module titles are attempts to represent the module theme.

The generic question context within which the module theme was to be developed was then determined. The judgment of context was again determined in terms of the rationale. For eleven-year-olds, the problem of development is considered in the context of "What is normal?" rather than "Why do things change?" "What is normal?" provides a more static context than change. It provides for description and variability without demanding a well-developed sense of time. It also provides for phenomenological study without separating multiple variables. The context

provides opportunities for successful (in student terms) experience for students who have developed concrete, but not formal, operational modes of thought.

Observations of eleven- to thirteen-year-olds indicated that many student concerns were in care and handling--nurturing--of animals. They did not find detailed measurement or observations meaningful. Possession of a feeling that particular animals were "mine" seemed to be very important for many children. This need for possession presented severe problems in classrooms where few animals were purchased. Our judgment about time-sense was supported by the inattention and lack of interest by students in development when developmental periods of animals were long.

The curriculum structure students work with most directly is the activity. A module consists of from twenty to thirty activities. Conceptually, activities should meet a complex set of criteria, criteria that are being formulated, tested, and revised as part of the dynamics of the curriculum development process. The creative act of developing activities can be inhibited if too many constraints are applied too early in the developmental process.

The criterion most difficult to achieve was expressed most clearly by Bateson (1972) when he stated: "We have to find the value of a planned act implicit in and simultaneous with the act itself, not separate from it in the sense that the act would derive its value from reference to a future end or goal." Within this general criterion each activity should engage the student with an important object or event, should provide practice in important process skills, and should be written

so most students at the grade level can understand what to do. Activities should be designed for individuals and small groups (two to three students). When possible, group size should be optional, but as the number of individuals to be involved is increased, the specification of roles must also be increased. Activities must also provide for a variety of ways of knowing--thinking, feeling, construction--and a variety of expressions of accomplishment--a completed object or data sheet, an informal discussion, a play, a poem, a story, a painting. Most activities should be non-sequential so students can choose from as many activities as possible in each module.

Modules need to include a variety of activities directed toward the module theme. The non-linear relationship of activities to each other is abridged only in special cases. For example, some direct experience activities include data gathering. Data from one or two activities can then be utilized in a higher cognitive level activity. Each module would seem to serve the diversity within the adolescent population if it included activities at concrete and at transition-to-formal operational levels. For eleven-year-olds, the proportion of concrete level activities would predominate, but the balance would shift toward more formal-level activities in the program for twelve- and thirteen-year-olds.

Choice of activities results in several to many different things going on in a classroom at one time. It also precludes full class discussion in the way usually practiced, for the whole class will not have had identical experiences. To reduce the pedagogical complexity, activities are grouped into problem areas within a module. If desired

by the teacher, choice can be restricted to a single problem area, breaking a module into smaller segments.

Logical coherence is provided by designing modules around an organizing theme, approached through two or three problem areas. Themes and problem areas are important in design, in creating activities, and in conceptualization by the teacher and other adults as to "what" students are studying. It does not seem as useful to many students. The conceptual relationships among the major design elements for the development of the curriculum materials are shown in Figure 3.

[Insert Fig. 3 here]

Physically, the experimental modules are taking several forms, but generally have compartments, drawers, or boxes for each activity with its media and materials, housed in a single large container. Audio tapes, sound slides, super 8mm film loops, and black-and-white photographs are utilized in activities as needed. The goal of the Human Sciences project is currently directed toward the development of materials that meet as many of the conceptual dimensions of program rationale as is possible. The theoretical framework for the Human Sciences program is being tested by developing and testing modules for a three-year program of studies. A more detailed account of the theoretical framework was published in Human Sciences: A Developmental Approach to Adolescent Education (1973). A final statement of the theoretical framework will not be completed until the curriculum materials have been tested and revised. It is unlikely that the framework presented here will not also undergo re-examination and reformulation in the development process.

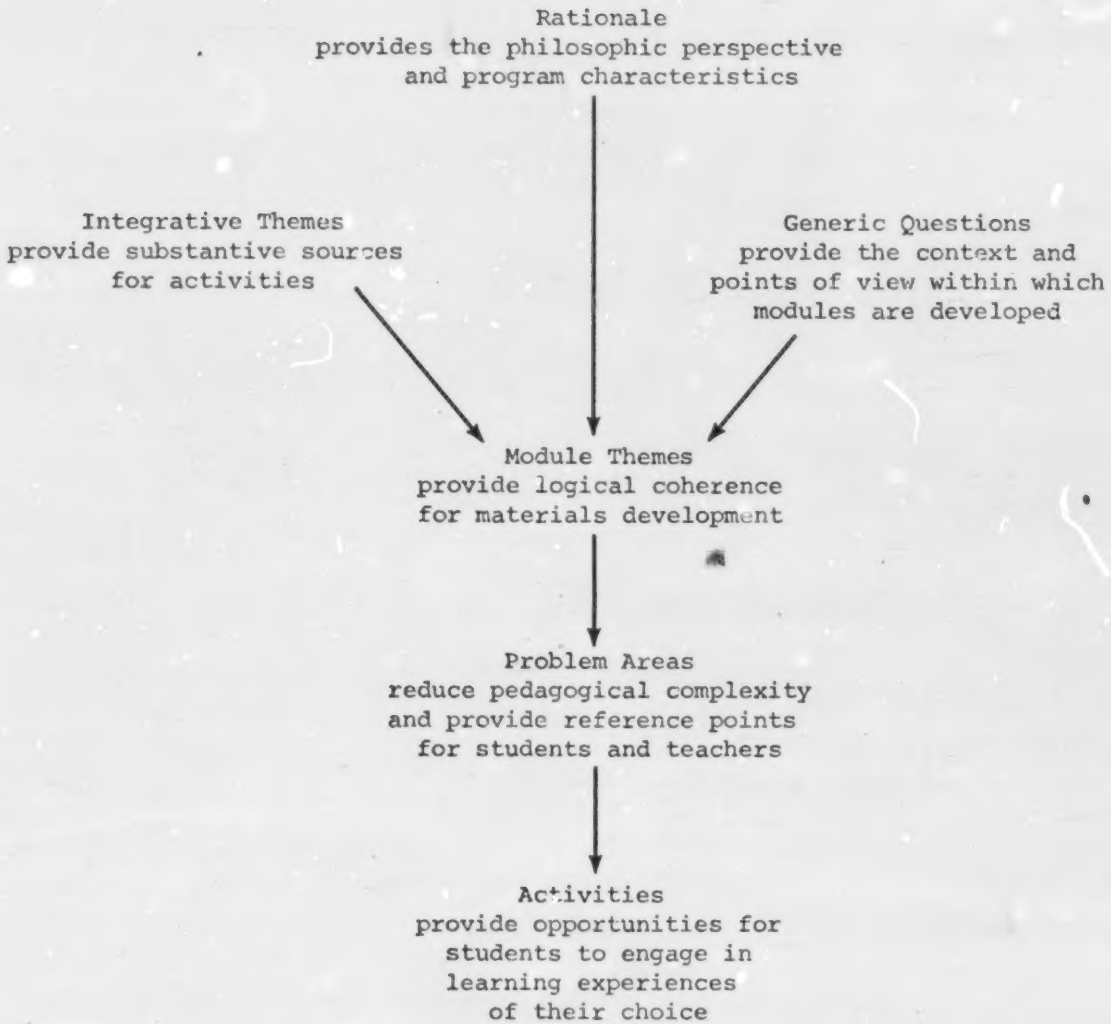

Figure 3. Conceptual structure of the Human Sciences curriculum materials.

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Figure 1. An illustration of variability: height of nineteen students in one class who chose the Human Sciences activity, "Self-study Booklet."

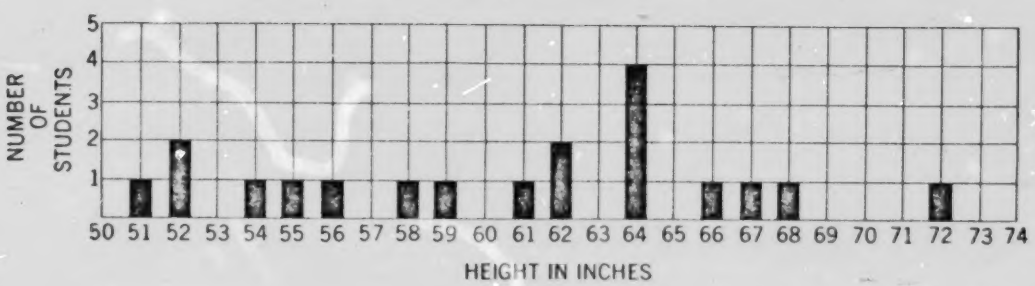
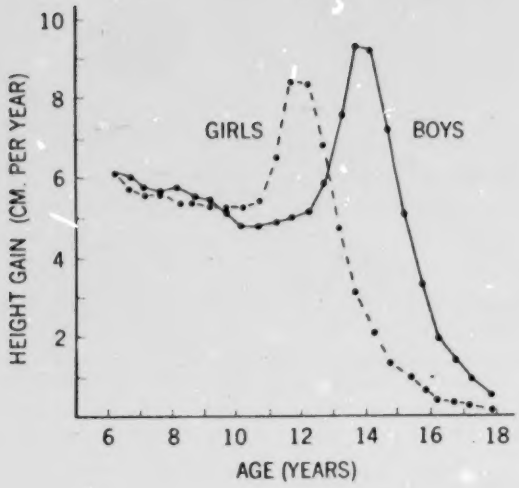

NUMBER OF STUDENTS
5
4
3
2
1
50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74
HEIGHT IN INCHES

Figure 2. Averaged growth rate for both boys and girls from ages six to eighteen. From Tanner, *Education and Physical Growth*.


HEIGHT GAIN (CM. PER YEAR)
10
8
6
4
2
GIRLS
BOYS
6
8
10
12
14
16
18
AGE (YEARS)